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CONTAMINATION OF VEGETATION AND SOIL BY LEAD AND OTHER ELEMENTS IN THE VICINITY OF THE CANADA METAL COMPANY, EASTERN AVENUE, TORONTO -1983,1984,1985

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INTRODUCTION

Phytotoxicology surveys of lead contamination of vegetation and/or soil near the Canada Metal Company (CMC), Toronto, have been conducted annually since 1972. Results of tree foliage sampling conducted in 1982 and earlier years have revealed elevated levels of lead, arsenic and antimony relative to the Gerrard Street Control Area in Toronto.

METHODS

In September of 1983, 1984 and 1985, samples of tree foliage were collected from 22 or 23 stations in the vicinity of the Canada Metal Company (Figure 1), from the sides of trees facing the company. Control samples of Ailanthus and Norway maple foliage also were collected in September of each year from 10 stations (total 20 samples) in the Gerrard Street Control Area in downtown Toronto (Figure 2).

In addition to vegetation sampling, soil sampling at each station was conducted in 1983 and 1985. Surface soil scrapings (0-1 cm depth) were collected in 1983 in order to estimate the degree of foliar contamination due to soil re-entrainment. Soil samples of 0-5 cm depth were collected in 1985 in order to determine whether a build-up of soil contaminants had occurred since 1980, the year 0-5 cm soil sampling had last been conducted.

Distance and direction of sampling stations were calculated with reference to a point located approximately equidistant from the main stack, the lead oxide building and the south cupola. This point is indicated by a star in Figure 1.

Vegetation and soil samples were processed in the Phytotoxicology laboratory, and were analyzed for lead (Pb), arsenic (As), cadmium (Cd), and antimony (Sb), all of which are potential emissions from CMC, by the MOE Laboratory Services Branch. Additionally, samples collected in 1983 were analyzed for titanium (Ti), which was used as a tracer to estimate soil re-entrainment of lead.

In this report, results are compared with those of earlier years and with Phytotoxicology Section "upper limits of normal" guidelines which were developed statistically (mean plus three standard deviations) from data for urban samples not considered to be influenced by emissions from industrial point sources.

RESULTS

Tree Foliage Results

Lead

Lead concentrations in unwashed tree foliage samples collected in September of 1983, 1984 and 1985 are shown in Table 1, and are compared with prior years' results. Average levels in 1985 were the same as in 1983, and had decreased only slightly from 1980 levels. However, foliar lead concentrations were significantly lower than in 1977. The percentage of stations having foliar lead concentrations exceeding the "upper limit of normal" (60 ppm) in 1985 was the lowest of any year since Phytotoxicology sampling began.

Effect of Rainfall

Washing of tree foliage samples collected near CMC in September of 1980, using a solution of 0.05% Alconox (soap) and EDTA (metal-complexing agent) reduced foliar lead levels by an average of 37% when compared with unwashed samples. Amount and timing of rainfall also might reduce lead concentration

results for samples analyzed "unwashed" in the lab, although the amount of such reduction might not be expected to be as large as that obtained by the relatively rigorous laboratory washing procedure. However, in order to ensure that inter-year comparisons of unwashed foliar lead results are valid, rainfall statistics should be examined. The figures in Table 2 show variation in rainfall, as measured at Pearson Airport, for the period 1977 to 1985. (Rainfall data for Toronto Island Airport were checked and were in close agreement with those for Pearson Airport). Total rainfall for the 2-week period and the 5-day period preceding the CMC sample collection dates are shown. The correlation coefficient between the 2-week rainfall and average foliar lead concentration was +0.54, while that between 5-day rainfall and foliar lead was +0.91 (significant at $p < 0.01$). These positive correlations are highly surprising. They indicate that increased rainfall was associated with increased foliar lead levels near CMC, whereas the opposite would be expected due to the washing effect of rainfall.

Because rainfall is known to decrease foliar concentrations of air-borne contaminants, the positive correlation with rainfall must be regarded as coincidental. The following are offered as explanations for its occurrence:

(a) The highest 5-day rainfall, and second highest 2-week rainfall, occurred in 1977, when CMC lead emissions were indeed less well controlled than they are presently (reflected in the foliar levels).

(b) The least amount of rainfall occurred in 1983 and 1985, when CMC lead emissions had in fact been reduced relative to earlier years, due to improved controls and better housekeeping.

Bearing these points in mind, it is possible that lead emissions from CMC have decreased significantly since 1980 (possibly excepting 1984), but that the expected decrease in foliar lead levels has been masked by lower than normal rainfall in the period preceding sample collection in 1983 and 1985.

Arsenic, Cadmium, Antimony

Arsenic, cadmium and antimony results for tree foliage collected near CMC in 1983, 1984 and 1985 are summarized in Table 3. Concentrations of arsenic and antimony considerably exceeded those in the Toronto control area, with the significance of the differences being antimony > arsenic. However, arsenic concentrations were considered to be within normal levels for an urban area. Average cadmium levels in CMC foliage also exceeded control area levels, but elevated CMC cadmium levels were associated with known cadmium accumulator species. Trends in foliar levels of arsenic, antimony and cadmium were similar to

lead, with average concentrations in 1985 and 1983 being approximately equal, and slightly lower than 1984 levels. These differences may be due to rainfall variations (Table 2).

Soil Results

Lead

Concentrations of lead in surface soil (0-5 cm depth) collected in 1985 in the vicinity of the Canada Metal Company are given in Table 4, and are compared with 1980 concentrations. (The 1983 results shown are for 0-1 cm depth and therefore direct comparisons cannot be made.) There is considerable variation inherent in soil sampling results, because metal levels in soils are seldom homogeneous even at a particular sampling station, especially in the vicinity of point sources. This variation, combined with possible site disturbances such as grading, resodding, etc., makes it risky to draw conclusions based on comparisons of single-site results for different years. However, it is possible to obtain a more valid indication of year-to-year changes in soil metal levels by comparing means for several stations. The data in Table 4 show that the average soil lead concentrations for the 22 CMC sampling stations decreased from 1584 ug/g in 1980 to 800 ug/g in 1985, a 49% reduction. In 1985, 43% of the sampling stations had above-normal (>500 ug/g) soil lead levels, compared with 73% in 1980.

Arsenic, Cadmium, Antimony

Mean soil levels of other contaminants near the Canada Metal Company also decreased from 1980 to 1985 (Table 5). The decreases for arsenic, cadmium and antimony averaged 67%, 53%, and 54%, respectively, during this period.

Decreases of this magnitude are somewhat surprising, because mobility of metals in soils is generally low, and decreases in soil levels may be slow to occur even after all current emissions have ceased. It is probable that reduced emissions from CMC, natural erosion of surface soil and soil ameliorative measures such as additions of clean fill, sodding, etc. have combined to effect these reductions in soil contaminant levels.

Estimating Re-entrainment Component of Foliar Lead Levels

As part of the 1983 sampling program, soil samples were collected from 0-1 cm depth in the vicinity of the regular foliar sampling stations near CMC. Samples of soil and unwashed foliage were analyzed for titanium in addition to the regularly monitored contaminants. Titanium is ubiquitous in soils at fairly uniform

concentrations and is not a component of emissions from secondary lead smelters. Also, it is not an essential element in plant nutrition and is not taken up by plants from soil. Therefore, the presence of titanium on unwashed tree foliage may be ascribed to soil re-entrainment. By comparing ratios of titanium and lead in both unwashed foliage and surface soil (0-1 cm depth), an estimate of lead in foliage due to soil re-entrainment may be obtained.

The results of this procedure are shown in Table 6. Re-entrained lead averaged 11% of total lead in foliage collected from 22 regular sampling stations near CMC in 1983.

In 1980, re-entrainment had been estimated to be responsible for approximately 30% of the lead content of unwashed foliage near CMC. However, the 1980 estimates are regarded as less reliable because 0-5 cm soil results and aluminum as a tracer (possible uptake by plants from soil) were utilized. Further, a decrease in the significance of re-entrainment from 1980 to 1985 would be expected due to the decrease in soil lead levels which occurred subsequent to 1980. Some natural year to year variation in the significance of re-entrainment also would be expected.

SUMMARY

Concentrations of lead, arsenic, and antimony in unwashed tree foliage collected in the vicinity of the Canada Metal Company in 1983, 1984 and 1985 were elevated with respect to the Gerrard Street Control Area in downtown Toronto.

Contaminant concentrations in unwashed tree foliage near CMC have shown little variation since 1980. However, relatively low amounts of rainfall prior to sample collection in recent years (1983 and 1985) may have masked the foliar effects of any actual decreases in contaminant emissions from CMC.

Average concentrations of lead, arsenic, cadmium and antimony in surface soil near CMC decreased significantly (by about one-half) from 1980 to 1985.

Soil re-entrainment was estimated in 1983 to have contributed an average of 11% of the lead content of unwashed tree foliage near CMC.

PH85/1

TABLE 1 - Lead concentrations (ug/g, dry wt.) in unwashed foliage samples collected in September of 1977 and 1979 through 1985 in the vicinity of the Canada Metal Co., Toronto

Station	Distance (m) and Direction from Reference Point	Species Sampled (1985)	Lead Concentration							
			1977	1979	1980	1981	1982	1983	1984	1985
NNW direction										
65	150 NNW	Norway maple	166	98	56	55	61	39	47	56
17	300 NNW	Norway maple	59	23	27	37	16	29	21	-
18	365 NNW	Norway maple	41	56	29	51	28	25	26	17
68	410 NNW	Norway maple	-	-	-	-	-	-	-	(17)
20	490 NNW	Silver maple	21	-	27	14	20	23	48	15
NNE direction										
2	200 NNE	Norway maple	292	740	98	108	100	86	160	125
1	190 N	Elm	124	-	158	91	184	92	155	136
9	240 N	Elm	152	-	124	83	122	113	255	47
11	360 N	Willow	52	-	46	33	50	39	70	28
67	400 N	Silver maple	-	-	-	-	-	-	-	(18)
12	485 N	Elm	49	-	70	16	81	55	78	62
13	575 N	Norway maple	100	-	17	28	16	36	22	22
15	730 NNE	Norway maple	34	-	12	19	11	11	10	11
NE direction										
5	470 E	Linden	27	-	40	46	34	47	38	38
ESE direction										
58	90 E	Ailanthus	560	-	128	142	119	94	26	96
59	200 ESE	Norway maple	142	193	98	54	25	38	38	90
66	495 SE	Poplar	-	-	42	24	17	42	60	42

Table 1 (cont'd)

Station	Distance (m) and Direction from Reference Point	Species Sampled (1985)	Lead Concentration 1977	1979	1980	1981	1982	1983	1984	1985
SW direction										
50	150 SW	Willow	214	117	110	113	119	77	175	51
44	330 SW	Willow	44	-	46	54	63	31	36	21
WNW direction										
33	200 NW	Norway maple	58	82	40	55	46	41	50	44
34	285 WNW	Norway maple	61	86	55	65	32	55	38	42
35	345 W	Silver maple	81	133	46	75	67	61	78	40
27	425 NW	Norway maple	69	56	49	27	42	32	31	39
28	500 WNW	Norway maple	31	39	17	30	19	35	27	25
CMC - Mean:			113	(147)	61	55	58	50	68	50
- Minimum:			21	23	12	14	11	11	10	11
- Maximum:			560	740	158	142	184	113	255	136
Control Area - Mean:			40	44	18	19	14.5	18.2	16.5	21.7
% of stations exceeding current "upper normal" level* (underlined):			52	64	32	32	41	27	32	22

* Note - Phytotoxicology Section "upper limit of normal" lead concentration in unwashed urban tree foliage is 60 ug/g.

Table 2

Rainfall Statistics (Pearson Airport)

Year	Vegetation Collection Dates (Canada Metal)	Rainfall in 2 week period prior to sample collection (mm)	Rainfall in 5 day period prior to sample collection (mm)	Average lead concentration (ug/g, dry weight) in unwashed CMC tree foliage samples
1977	Sept. 27	99.8	67.7	113
1979	Sept. 18	42.7	36.6	-
1980	Sept. 23	35.9	19.3	61
1981	Sept. 24	20.4	15.8	55
1982	Sept. 27	123.9	37.2	58
1983	Sept. 13, 14	1.2	0	50
1984	Sept. 11	64.5	27.1	68
1985	Sept. 16	36.6	0	50

Table 3

Summary of arsenic, cadmium and antimony levels (ug/g, dry weight) in unwashed tree foliage near the Canada Metal Company - 1983, 1984, 1985

Statistical Parameter	Arsenic	Cadmium	Antimony
1983 - mean	0.41	0.50	0.83
- minimum	0.10	< 0.1	0.24
- maximum	0.77	3.8	2.1
- % of stations with "above-normal" concentrations	0	4.5**	77
- control area mean	0.12	< 0.1	0.11
1984 - mean	0.52	0.62	1.16
- minimum	0.10	< 0.1	0.14
- maximum	1.5	4.4	4.8
- % of stations with "above-normal" concentrations	0	4.5**	68
- control area mean	0.19	< 0.1	0.07
1985 - mean	0.37	0.55	0.90
- minimum	0.12	< 0.1	0.16
- maximum	0.91	4.6	3.6
- % of stations with "above-normal" concentrations	0	4.3**	57
- control area mean	0.21	< 0.1	0.21
Phytotoxicology Section "upper limits of normal" concentrations in unwashed urban tree foliage	2	3*	0.5

* under review

** "Above-normal" cadmium concentrations were present in known cadmium accumulator species only.

Table 4

Lead concentrations (ug/g, dry weight) in surface soil collected in the vicinity of the Canada Metal Company - 1980, 1983, 1985

Station No.	Distance (m) and Direction from Reference Point	Lead Concentration 1980 (0-5 cm)	1983 (0-1 cm)	1985 (0-5 cm)	% Change 1980-1985
65*	150 NNW	225	2670	370	64
17*	300 NNW	615	860	-	-
18*	365 NNW	630	970	920	46
68*	410 NNW	-	-	205	-
20*	490 NNW	1630	760	42	-97
2	200 NNE	4210	2600	1450	-66
1*	190 N	910	2070	1900	109
9*	240 N	1150	1000	1500	30
11*	360 N	95	180	260	174
67*	400 N	-	-	215	-
12	485 N	4000	2030	1300	-68
13*	575 N	730	690	465	-36
15*	820 NNE	500	430	290	-42
5	470 NE	420	1470	335	-20
58	90 E	8250	820	330	-96
59	200 ESE	1050	1100	990	-6
66	495 SE	1060	970	700	-34
50	150 SW	4480	250	330	-93
44	330 SW	155	89	28	-82
33*	200 NW	840	1930	1850	120
34*	285 WNW	840	730	990	18
35*	345 W	1960	2430	3200	63
27*	425 NW	700	530	460	-34
28*	500 WNW	400	350	285	-29
Mean soil lead concentration:		1584	1130	800	-49
Control area mean concentration:		353	750	316	-10.5
% of stations exceeding current "upper normal" level (underlined):		73	-	43	

Note - Phytotoxicology Section "upper limit of normal" lead concentration in urban soil (0-5 cm depth) is 500 ug/g.

* Sampling station located on residential or public property (residential boulevards, parkland).

Table 5

Summary of arsenic, cadmium and antimony levels (ug/g, dry weight) in surface soil near the Canada Metal Company - 1980, 1983, 1985

Statistical Parameter	Arsenic	Cadmium	Antimony
1980 (0-5 cm depth)			
- mean	35.5	3.2	35.0
- minimum	4.0	<0.5	1.5
- maximum	156	10.5	145
- % of stations with "above-normal" concentrations	45	23	73
- control area mean	7.2	1.0	3.9
1983 (0-1 cm depth)			
- mean	10.2	1.9	16.0
- minimum	2.2	<0.2	0.9
- maximum	31.0	6.0	64.9
- control area mean	4.0	1.1	1.6 (35.5)
1985 (0-5 cm depth)			
- mean	11.8	1.5	16.0
- minimum	1.0	<0.2	0.36
- maximum	34.8	3.8	87.4
- % of stations with "above-normal" concentrations	13	0	43
- control area mean	5.9	0.86	2.9
Phytotoxicology Section "upper limits of normal" concentrations in urban surface soil (0-5 cm depth)	20	4	8

Table 6

Estimated contribution from soil re-entrainment to lead content of tree foliage in the vicinity of the Canada Metal Company (CMC), Toronto - September, 1983.

Sample Group	Statistics	Tree Foliage (unwashed)			Surface Soil (0-1 cm)			Estimated ppm Pb in Foliage due to Re-entrainment (off property)	Re-entrained Pb as % of Total Pb	Enrichment Factor (E.F.)**
		Pb (ppm)	Tl (ppm)	Pb/Tl	Pb (ppm)	Tl (ppm)	Pb/Tl			
"High Pb" CMC stations (>40 ppm Pb, mean distance 275 m from CMC) (n=11)	Mean ± S.D.*	69.4 ± 24.2	13.4 ± 4.2	5.9 ± 3.2	1480 ± 775	2720 ± 390	0.56 ± 0.30	7.9 ± 5.9	13.0 ± 9.4	21 ± 34
	Minimum	41	6.6	2.7	250	2200	0.10	0.66	0.86	3.9
	Maximum	113	22	12	2600	3580	0.99	22	27	120
"Low Pb" CMC stations (<40 ppm Pb, mean distance 410 m from CMC) (n=11	Mean ± S.D.	30.7 ± 8.5	10.9 ± 2.2	3.0 ± 1.2	785 ± 700	3330 ± 440	0.23 ± 0.18	2.6 ± 2.1	9.0 ± 6.1	32 ± 53
	Minimum	11	5.3	0.92	89	2740	0.031	0.16	0.52	5.0
	Maximum	39	13	5.8	2670	4120	0.70	7.7	20	187
All CMC stations (mean distance 345 m from CMC) (n=22)	Mean ± S.D.	50 ± 27	12 ± 3.5	4.4 ± 2.8	1130 ± 805	3020 ± 510	0.39 ± 0.30	5.3 ± 5.1	11 ± 8.0	27 ± 44
	Minimum	11	5.3	0.92	89	2200	0.031	0.16	0.52	3.9
	Maximum	113	22	12	2670	4120	0.99	22	27	187
Gerrard Street Control Area, Toronto (n=20)	Mean ± S.D.	18 ± 7.8	13 ± 4.0	1.5 ± 0.89	750 ± 870	3250 ± 390	0.23 ± 0.25	2.7 ± 2.6	17 ± 13	12 ± 13
	Minimum	7	7.0	0.47	230	2260	0.066	0.59	1.6	1.9
	Maximum	36	21	4.0	3130	3620	0.90	12	55	61

*S.D. = Standard Deviation

**E.F. = $(Pb_{(F)}/Tl_{(F)}) \div (Pb_{(S)}/Tl_{(S)})$

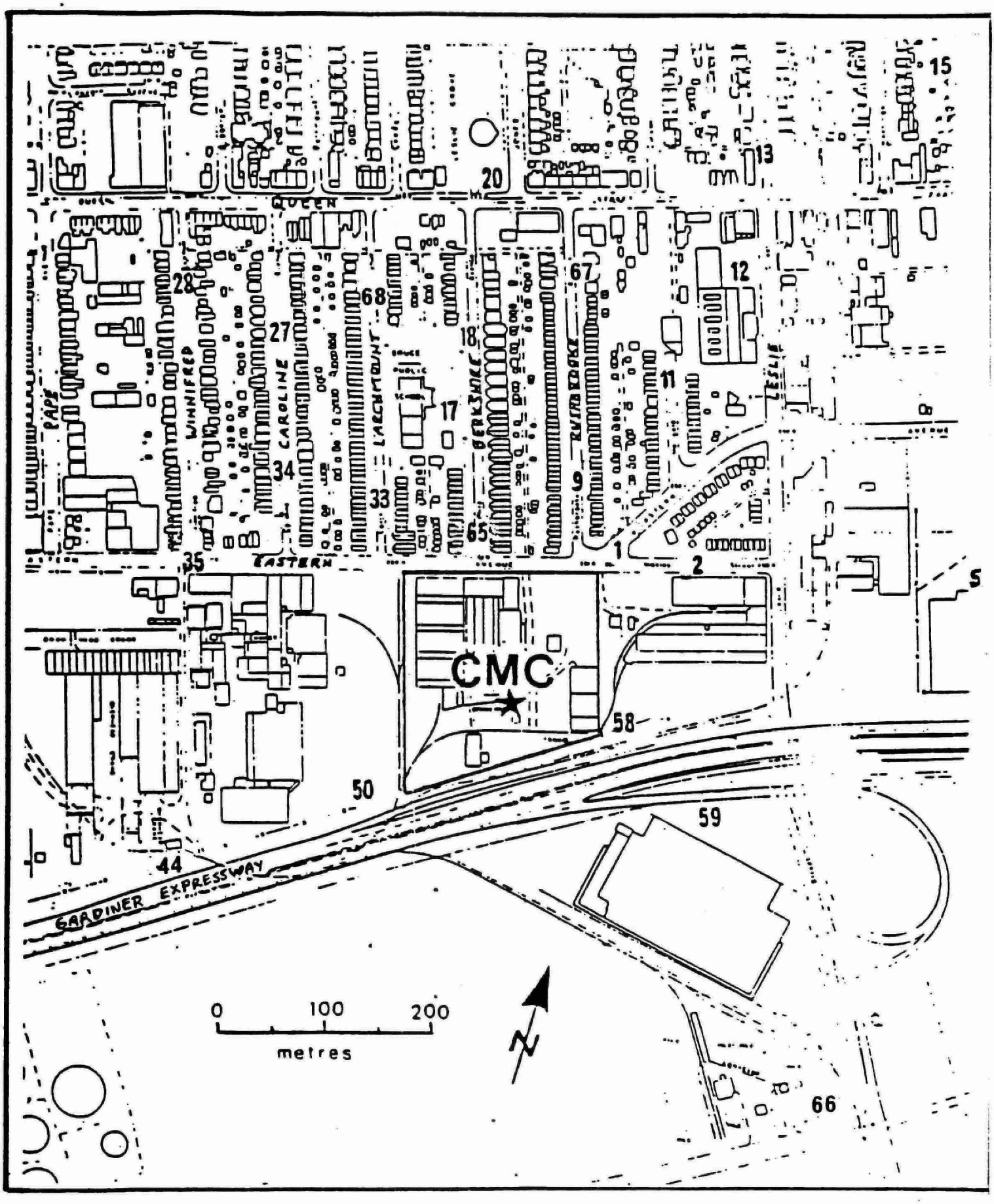


Figure 1

Approximate locations of sampling stations in the vicinity of Canada Metal Company, Toronto.

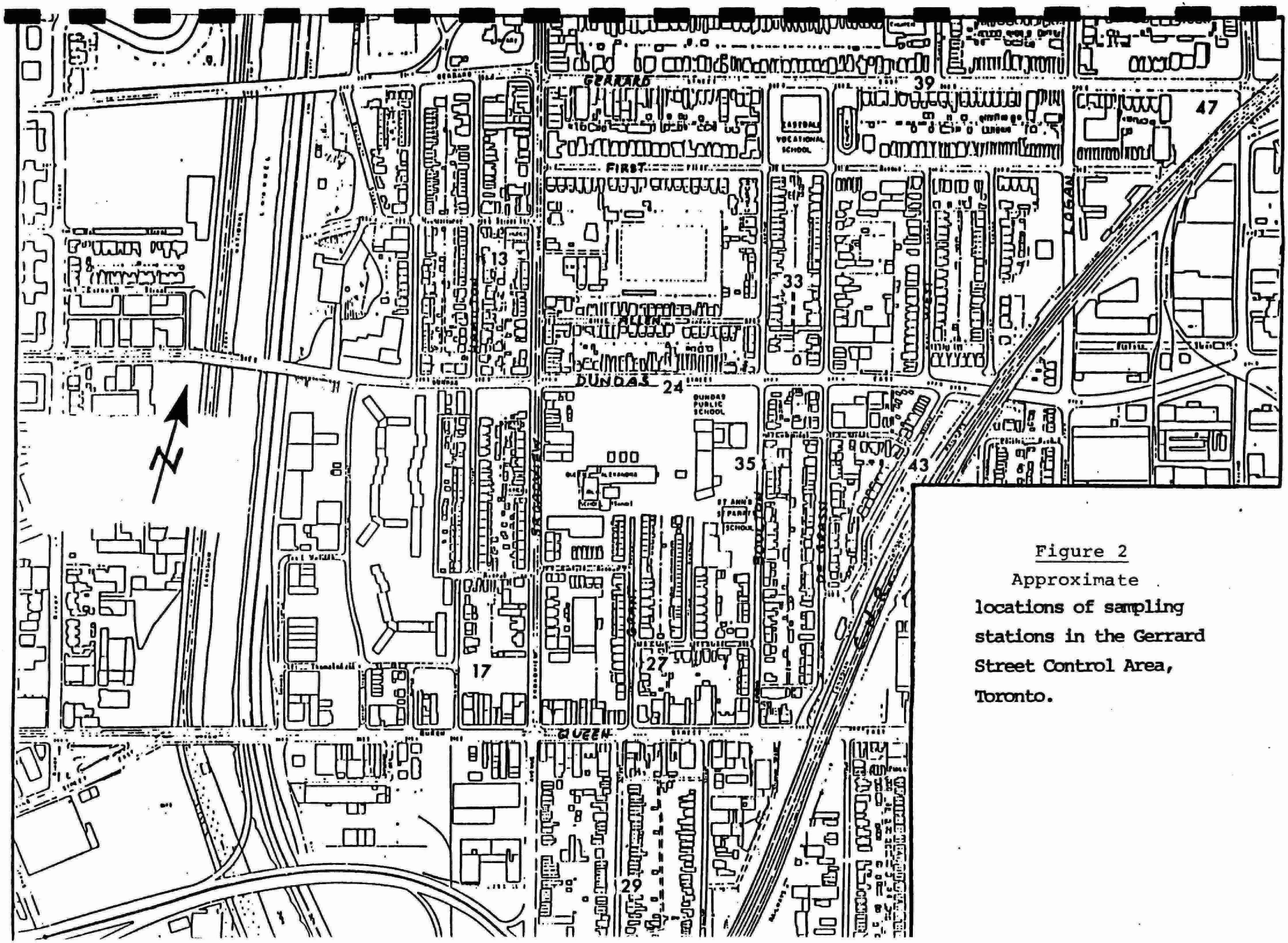
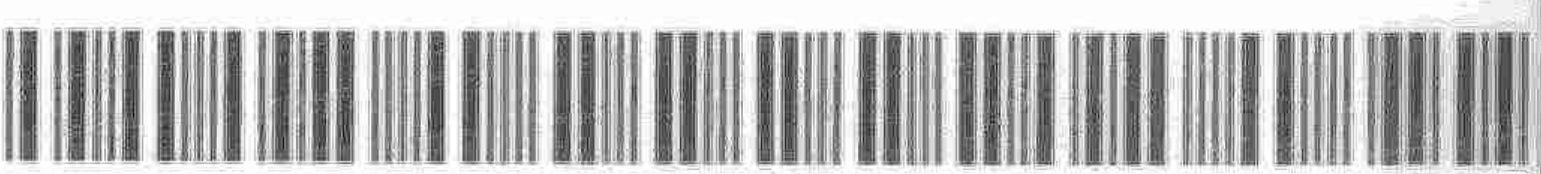


Figure 2

Approximate locations of sampling stations in the Gerrard Street Control Area, Toronto.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